E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(12): 458-461
Received: 13-09-2025
Accepted: 17-10-2025

Yogeshwar N
M.Sc. Scholar, Department of Agronomy, Professor Jayashankar Telangana Agricultural University, Hyderabad, Telangana, India

Pragathi Kumari CH
Professor & HOD, Department of Agronomy, Agricultural College, Palem, PJTAU, Hyderabad, Telangana, India

Mahender Kumar R
Principal Scientist & Head, Crop Production Section, Department of Agronomy, ICAR-IIRR, Rajendranagar, Hyderabad, Telangana, India

Ramprakash T
Principal Scientist, SS&AC RARS Palem, PJTAU, Hyderabad, Telangana, India

Corresponding Author:
Yogeshwar N
M.Sc. Scholar, Department of Agronomy, Professor Jayashankar Telangana Agricultural University, Hyderabad, Telangana, India

Comparative bio-efficacy of drone and knapsack applied sequential herbicides on growth and productivity of wet direct-seeded rice (*Oryza sativa* L.) (WDSR)

Yogeshwar N, Pragathi Kumari CH, Mahender Kumar R and Ramprakash T

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i12g.4414

Abstract
An agronomic investigation was conducted during the *rabi* season of 2024-25 at the B1 plot of the Indian Institute of Rice Research, Rajendranagar, Hyderabad, to assess the comparative bio-efficacy of drone- and knapsack-based herbicide sprays in Wet Direct Sown Rice. The trial was laid out in a randomized block design with six treatments and four replications. The treatments included pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 + 15 g a.i. ha^{-1} (Ready mix) PE 3-5 DAS followed by triafamone 20% + ethoxysulfuron 10% WG 44 + 22.5 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS, pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 +15 g a.i. ha^{-1} (Ready mix) PE 3-5 DAS followed by penoxsulam 1.02% + cyhalofop-butyl 5.1% OD 135 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through drone and knapsack spray. Among these, pre-emergence application of pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG @ 600 +15 g a.i. ha^{-1} (Ready mix) at 3-5 DAS followed by penoxsulam 1.02% + cyhalofop-butyl 5.1% OD 135 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through drone spray resulted, in superior plant height (cm), no. of panicle m^{-2}, no. of filled grains $panicle^{-1}$, test weight (g), besides superior grain yield.

Keywords: Nanourea, conventional urea, growth, LAI, yield and wheat

Introduction
Rice (*Oryza sativa* L.) serves as a crucial staple food for over half of the world's population, playing an essential role in both present and future food security globally. It accounts for 32-59% of dietary energy and 25-44% of dietary protein in 39 countries. To sustain the current per capita availability of rice (69 kg per year), the projected demand for rice needs to increase by 70% over the next three decades (Patra and Haque, 2011) [1]. In India, there are 478.3 lakh hectares dedicated to rice farming, yielding 1357.5 lakh tonnes of rice (IndiaStat, 2024) [2], which makes up 28% of the global rice production (USDA, 2024) [3]. Although this is a significant proportion, India's rice productivity is relatively low compared to other major rice-producing countries like China (4.3 t ha^{-1}), Australia (10.1 t ha^{-1}), the United States (7.5 t ha^{-1}), and Russia (5.2 t ha^{-1}) (Yadav *et al*., 2019) [4]. The rice crop faces numerous biotic and abiotic challenges. Among the biotic challenges, weeds are a significant factor limiting yield, and they vary based on the cultivation conditions. Traditionally, paddy farming involves planting rice seedlings in puddled fields, which requires intensive labor for nursery management and manual transplanting. Direct drum seeding offers a practical alternative, simplifying the process while maintaining productivity. However, the adoption of direct-seeding technology may lead to shifts in weed flora towards more competitive and harder-to-control grasses and sedges. A key barrier to the widespread use of direct seeding is weed infestation. Unmanaged weeds have been reported to reduce yields by 96% in dry direct-seeded rice (DSR) and by 61% in wet DSR (Saravanane *et al*., 2021) [5]. Conducting hand weeding at early stages is difficult, making herbicides the most effective and economically feasible method for weed management in wet direct-seeded rice. Employing drones for herbicide spraying enables Site-Specific Weed Management (SSWM), which allows for targeting weed patches specifically or modifying herbicide application based on weed density or species composition. This approach conserves

time, water, and application costs, as well as minimizes the residual environmental impact (Medlin and Shaw, 2000) [6]. However, research on the effectiveness of herbicides applied using drones is quite limited. Recommended herbicide dosages are based on achieving maximum weed control, but when utilizing unmanned aerial vehicles (UAVs) or drones for herbicide application at lower spray volumes (40 L ha^{-1}) as opposed to conventional knapsack sprayers that operate at higher volumes (500 L ha^{-1}), it may be necessary to adjust the herbicide dosage to ensure effective weed management and optimal crop yield. Consequently, studies are needed to assess the efficacy of herbicide combinations (especially ready-mix) for controlling a wider range of weed types and promoting safer crop production.

Materials and Methods

A field experiment was conducted at B1 plot Indian Institute of Rice Research, Rajendranagar, Hyderabad during *rabi*, 2024-25. The soil type was clay loam and neutral in nature (pH 7.6), having an EC of 0.71 dS m^{-1}, organic carbon (0.45%), available nitrogen (21 kg ha^{-1}), phosphorous (28 kg ha^{-1}) and potassium (452.6 kg ha^{-1}). The experiment was laid out in randomized block design with 6 treatments with 4 replications. The treatments were T_1, T_2: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @600 + 15 g a.i. ha^{-1} (Ready mix) PE 3-5 DAS followed by Triafamone 20% + Ethoxysulfuron 10% WG 44 + 22.5 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through drone and knapsack spray, T_3, T_4: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 +15 g a.i. ha^{-1} (Ready mix) PE 3-5 DAS followed by Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD 135 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through drone and knapsack spray, T_5: hand weeding at 20 and 40 DAS, and T_6: weedy check. Jagithyla rice (JGL 24423) was sown at the rate of 35 kg ha^{-1}. Sowing was done with drum seeder with a spacing of 20 cm between the rows. The fertilizers applied in the form of urea, di ammonium phosphate and murate of potash at a dose of 120:60:40 N, P_2O_5, K_2O kg ha^{-1}, respectively. Pre and post emergence herbicide application was done using 500 litters of water ha^{-1} as spray fluid with flat fan nozzle in knapsack sprayer and 40 litters water ha^{-1} using drone. The observations on plant height (cm), no. of panicle m^{-2}, no. of filled grains $panicle^{-1}$, test weight (g) and grain yield kg ha^{-1} at harvest were recorded.

Results and Discussion

Plant height

The height of wet direct sown rice was notably affected by the weed management strategies that incorporated both drone and knapsack herbicide applications (Table 1). The tallest plants were observed in T_5: Hand weeding at 20 and 40 DAS (98.6 cm), which was significantly better than all the herbicide treatments and the unweeded control, indicating nearly weed-free conditions throughout the crop's growth period. Among the herbicide treatments, T_3: Pretilachlor 30% + Pyrazosulfuron ethyl 0.75% WG @600 + 15 g a.i. ha^{-1} (Ready mix) applied as PE at 3-5 DAS followed by Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD @135 g a.i. ha^{-1} (Ready mix) applied as PoE at 20-25 DAS via drone spray achieved a significantly greater plant height (93.0 cm). Next, T_1: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @6000 + 15 g a.i. ha^{-1} (Ready mix) applied as PE 3-5 DAS followed by Triafamone 20% + Ethoxysulfuron 10% WG 44 + 22.5 g a.i. ha^{-1} (Ready mix) applied as PoE 20-25 DAS through drone spray (87.1 cm) was comparable to T_4 (85.5 cm). The superior performance of the drone-applied treatments was attributed to consistent droplet distribution, enhanced penetration of the canopy, and timely application, which led to effective suppression of weeds in both early and late seasons. The shortest plant height was noted in T_6: Unweeded check (73.5 cm), which was significantly worse than all other treatments due to intense weed competition for nutrients, moisture, and light. A similar increase in plant height due to the effective sequential application of herbicides with drones in DSR has been documented by Naveen *et al*. (2023) [7] and Paul *et al*. (2024) [9].

Number of panicles (m^{-2})

The number of panicles per square meter significantly differed due to various weed management practices (Table 1). The highest number of panicles per square meter (301.0) was observed in a weed-free condition achieved with two hand weedings at 20 and 40 days after seeding (T_5), which was statistically better than all other treatments. Among the herbicide treatments, the drone-applied Pretilachlor + Pyrazosulfuron (PE) followed by Penoxsulam + Cyhalofop-butyl (T_3) resulted in a significantly higher count of panicles per square meter (277.8). This was succeeded by the drone-applied Pretilachlor + Pyrazosulfuron (PE) followed by Triafamone + Ethoxysulfuron (PoE), which recorded 255.1 panicles per square meter. These two sequential herbicide applications proved to be more effective in weed control compared to the same sequential herbicides applied with a knapsack sprayer (i.e., T_4 and T_2). These findings align closely with those reported by Paul *et al*. (2023) [10].

The lowest count of panicles m^{-2} (196.7) was noted in T_6: the unweeded control, highlighting the detrimental impact of ongoing weed competition on yield. The reduced number of panicles in the unweeded control was due to the intense competition from weeds for space, light, and nutrients throughout the crop growth period, consistent with observations made by Satapathy *et al*. (2017) [11].

No. of filled grains $panicle^{-1}$ and Test weight (g)

The number of filled grains per panicle and test weight (g) of WDSR were notably affected by the different weed management practices (Table 1). A significantly higher count of filled grains per panicle (224.6) was observed under the weed-free condition achieved by conducting two hand weedings at 20 and 40 days after sowing (DAS) (T_5). This was statistically superior to all other treatments. Among the herbicide treatments, the drone-applied combination of Pretilachlor + Pyrazosulfuron (PE) followed by Penoxsulam + Cyhalofop-butyl (T_3) led to a significantly greater number of filled grains (208.8 per panicle). This was succeeded by the drone-applied Pretilachlor + Pyrazosulfuron (PE) followed by Triafamone + Ethoxysulfuron (PoE), which recorded 192.6 filled grains per panicle. These two sequential herbicide applications exhibited more effectiveness in weed control compared to similar sequential herbicides applied with a knapsack sprayer (i.e., T_4 and T_2), allowing sufficient resources to be available at or after anthesis to enhance the photosynthesis rate and providing additional time for carbohydrate translocation to the grains (Cowan *et al*., 1998), thereby increasing the number of filled grains. The lowest count of filled grains (137.7 per panicle) was seen in T_6: unweeded check, illustrating the yield-reducing impact of persistent weed competition. Test weight (g) showed no significant differences with the weed management practices (Table 1). This could be attributed to the fact that test weight is primarily influenced by the crop plant's genotype.

Grain yield (kg ha^{-1})

Grain yield varied significantly in wet direct seeded rice (Table 1), demonstrating the cumulative influence of weed management practices on crop growth and yield characteristics. Treatment T_5: Hand weeding at 20 and 40 days after seeding (DAS) resulted in the highest grain yield (6855 kg ha^{-1}), which was significantly better than all other treatments. Among the herbicide treatments, T_3: Drone application of Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 + 15 g a.i. ha^{-1} (Ready mix) applied at 3-5 DAS followed by Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD 135 g a.i. ha^{-1} (Ready mix) applied at 20-25 DAS achieved the highest grain yield (6296 kg ha^{-1}), which was statistically superior to the other treatments. The next best result came from T_1: Drone applied Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 + 15 g a.i. ha^{-1} (Ready mix) applied at 3-5 DAS followed by Triafamone 20% + Ethoxysulfuron 10% WG 44 + 22.5 g a.i. ha^{-1} (Ready mix) applied at 20-25 DAS, yielding 5708 kg ha^{-1}, which was comparable to T_4: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 + 15 g a.i. ha^{-1} (Ready mix) applied at 3-5 DAS followed by Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD 135 g a.i. ha^{-1} (Ready mix) applied at 20-25 DAS through a knapsack sprayer (5605 kg ha^{-1}). Following that, T_2: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 + 15 g a.i. ha^{-1} (Ready mix) applied at 3-5 DAS followed by Triafamone 20% + Ethoxysulfuron 10% WG 44 + 22.5 g a.i. ha^{-1} (Ready mix) applied at 20-25 DAS through a knapsack sprayer resulted in a lower yield (5064 kg ha^{-1}) among the herbicide treatments due to its reduced effectiveness in controlling weeds with knapsack application. The increased yield observed under drone spraying is likely due to the precise and uniform delivery of herbicides, leading to enhanced weed control efficiency and better crop growth throughout the season. Conversely, T_6: The unweeded control recorded the lowest grain yield (2105 kg ha^{-1}), indicating significant yield losses as a result of extended weed competition. These results are in line with previous studies conducted by Paul *et al*. (2023) [10], Naveen *et al*. (2023) [7], Sree *et al*. (2024) [12], and Naveen *et al*. (2025) [8], who highlighted the effectiveness of drone herbicide applications in maximizing rice yields.

Table 1: Effect of drone and knapsack based herbicide spraying on growth and yield of wet direct seeded rice

Treatments	Plant height (cm)	No. of panicle m^{-2}	No. of filled grains panicle^{-1}	Test weight (g)	Grain yield (kg ha^{-1})
T_1: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @600 + 15 g a.i. ha^{-1} (Ready mix) PE 3-5 DAS followed by Triafamone 20% + Ethoxysulfuron 10% WG 44 + 22.5 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through Drone spray	87.1	255.1	192.6	19.1	5708
T_2: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 + 15 g a.i. ha^{-1} (Ready mix) PE 3-5 DAS followed by Triafamone 20% + Ethoxysulfuron 10% WG 44 + 22.5 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through knapsack sprayer	80.1	227.5	172.5	18.8	5064
T_3: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 +15 g a.i. ha^{-1} (Ready mix) PE 3-5 DAS followed by Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD 135 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through Drone spray	93.0	277.8	208.8	19.2	6296
T_4: Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 +15 g a.i. ha^{-1} (Ready mix) PE 3-5 DAS followed by Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD 135 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through knapsack spray	85.5	250.7	188.4	19.0	5605
T_5: Hand Weeding (20 and 40 DAS)	98.6	301.0	224.6	19.3	6855
T_6: Unweeded check	73.5	196.7	137.7	18.6	2105
S.Em ±	1.79	7.36	5.17	0.34	175
CD (P=0.05)	5.21	22.01	15.47	NS	530

Conclusion

Pre-emergence application of Pretilachlor 30% + Pyrazosulfuron Ethyl 0.75% WG @ 600 +15 g a.i. ha^{-1} (Ready mix) at 3-5 DAS followed by Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD 135 g a.i. ha^{-1} (Ready mix) PoE 20-25 DAS through drone can be recommended for obtaining superior yield provided uniform and precise application, timely weed control, cost effective comparable to weed-free check, higher weed control efficiency and yield attributes in wet direct sown rice.

References

1. Patra PS, Haque S. Effect of seedling age on tillering pattern and yield of rice (*Oryza sativa* L.) under system of rice intensification. ARPN J Agric Biol Sci. 2011;6(11):33-35.
2. Indiastat. Most comprehensive e-resource for socio-economic statistical data India. 2024 May 6. https://www.indiastat.com
3. United States Department of Agriculture (USDA). Production, supply and distribution data. 2024. https://www.fas.usda.gov/data/production/commodity/0422110
4. Yadav DB, Singh N, Duhan A, Yadav A, Punia SS. Penoxsulam influence on weed complex and productivity of transplanted rice and its residual effects in rice-wheat cropping system. Indian J Weed Sci. 2019;51(1):10-14.
5. Saravanane P, Pavithra M, Vijayakumar S. Weed management in direct seeded rice. Indian Farming. 2021;71(4):61-64.
6. Medlin CR, Shaw DR. Economic comparison of broadcast and site-specific herbicide applications in nontransgenic and glyphosate-tolerant *Glycine max*. Weed Sci. 2000;48(5):653-661.
7. Naveen L, Bhatt PS, Rekha KB, Ramprakash T. Assessment of post emergence herbicide efficacy for drone spraying in transplanted rice (*Oryza sativa* L.). Int J Environ Clim Change. 2023;13:3281-3288.
8. Naveen L, Bhatt PS, Rekha KB, Ramprakash T. Evaluation of drone-applied post-emergence herbicides on weed management and grain yield in transplanted rice (*Oryza sativa* L.). Plant Arch. 2025;25(1):156-166.
9. Paul R, Arthanari PM, Pazhanivelan S, Kavitha R, Djanaguiraman M. UAV-based herbicide application for efficient weed management in direct-seeded rice. Agric Sci Dig. 2024;44(2):295-300.
10. Paul RAI, Arthanari PM, Pazhanivelan S, Kavitha R,

Djanaguiraman M. Drone-based herbicide application for energy saving, higher weed control and economics in direct-seeded rice (*Oryza sativa*). Indian J Agric Sci. 2023;93(7):704-709.
11. Satapathy BS, Duary B, Saha S, Pun KB, Singh T. Effect of weed management practices on yield and yield attributes of wet direct-seeded rice under lowland ecosystem of Assam. Oryza. 2017;54(1):29-36.
12. Sree CV, Bhatt PS, Rekha KB, Ram T. Influence of post emergence herbicide through drone spraying using different nozzles on the growth and yield of transplanted rice (*Oryza sativa* L.). Int J Res Agron. 2024;SP-7(9):35-38.
13. Venkatesh B, Parameswari YS, Madhavi M, Prakash TR. Performance of herbicides and herbicide mixtures on weed control in transplanted rice. Indian J Weed Sci. 2021;53(2):179-181.
14. Atheena A, Prameela P, Menon VM. Tank mix application of cyhalofop-butyl with selected herbicides for weed control in wet-seeded rice. Indian J Weed Sci. 2017;49(3):283-286.
15. Kashid NV. Integration of post-emergence herbicide application with hand weeding for managing weeds in transplanted rice. Indian J Weed Sci. 2019;51(2):206-208.
16. Ramesha YM, Anand SR, Krishnamurthy D, Bhanuvally M. Weed management effect to increase grain yield in dry direct-seeded rice. Indian J Weed Sci. 2019;51(1):6-9.
17. Singh K, Singh S, Pannu RK. Efficacy of pendimethalin and cyhalofop-butyl + penoxsulam against major grass weeds of direct-seeded rice. Indian J Weed Sci. 2019;51(3):227-231.